IX. *Obſervations upon Lightning, and the Method of ſecuring Buildings from its Effects: In a Letter to Sir* Charles Frederick, *Surveyor-General of His Majeſty's Ordnance, and F. R. S. By* Benjamin Wilſon, *F. R. S. & Ac. R.* Upſ. *Soc.*

SIR,

YOUR ſtation, as Surveyor-General of His Majeſty's Ordnance, being ſuch, as makes the ſubject of this paper particulary intereſting to you, I preſume an apology for this addreſs will be wholly unneceſſary.

Upon an application of the Board of Ordnance to the Royal Society, in July laſt, a committee was appointed, to conſider of the propereſt method for ſecuring the *Magazine* at *Purfleet* from miſchief by lightning: which committee reported to the council of that learned body, what they thought neceſſary to be done upon that occaſion. The council, afterwards, tranſmitted to the board, a copy of that report, together with another paper written by myſelf, in conſequence thereof.

For, during the conſideration of that buſineſs, ſome doubts having ariſen in my mind, with regard to the propriety of *points*, which were propoſed to terminate the top of each conductor; and thoſe doubts being founded upon experiments and obſervations, I could not conſiſtently ſubſcribe to that report, nor ſuppreſs my opinion, on a ſubject of ſuch importance.

Whatever may be the ſentiments of others reſpecting thoſe doubts, yet, they being the reſult of my mature conſideration, I thought it my duty to propoſe them to the committee; and further to expreſs my diſſent, in writing, to that particular part of their report: giving, at the ſame time, ſome of the principal reaſons for ſuch diſſent; and referring them, for further ſatisfaction on this ſubject, to a letter which is already publiſhed in the Tranſactions of the Royal Society.

As that diſſent is the origin of this paper, a copy of it is here inſerted. See page 48 of this Volume.

AGREEABLE to the declaration at the end of the above diſſent, I ſhall now proceed to offer my further reaſons for objecting to pointed conductors.

Experience, which is our beſt guide in all phyſical enquiries, but particularly in electrical ones, every day convinces me, that we know but little of that ſubtile fluid, which operates ſo *ſecretly*, and at the ſame time ſo powerfully, upon the earth, and its atmoſphere I confeſs that I am even now leſs acquainted with the principle of its action, than I thought I was twenty years ago: the *ſmalleſt dif-*

ferences in the circumſtances of our experiments, frequently cauſing very material differences in their reſults. And perhaps no one, who has not applied his mind cloſely to enquiries of this kind, could conceive how the *pointing* a piece of metal, or *not*, ſhould make any material difference in the experiment.

The electrician has it always in his power to convince any one of the fact, who, through inexperience, may be inclined to entertain the leaſt ſcruple about it: for *even from thoſe experiments* to which it was thought proper to appeal at the committee, it appeared, that the difference in the effects upon this fluid, between *pointed* and *blunted* metal, is as 12 to 1.

A thunder-cloud therefore, according to that reaſoning, (the circumſtances of it being ſuppoſed to be nearly ſimilar with what is called the prime-conductor in thoſe experiments), if it acted at 1200 yards diſtance upon a point, would require a blunted end to be brought within the diſtance of 100 yards; and beyond thoſe limits, would paſs over it, without affecting it at all. On this occaſion permit me to obſerve, that the *longer* the conductors are above any building, the *more danger* is to be apprehended from them; as they will in that caſe approximate nearer in their effects to thoſe that are pointed. And that is one reaſon why I was not for adviſing the propoſed conductors at *Purfleet*, to be ſo high as *ten feet* above the magazines, and more particularly upon that building called the *Board-houſe*, which ſtands conſiderably higher than the magazines themſelves.

But, before we advance farther into this ſubject, it may be proper to ſhew the reaſons for introducing a *pointed apparatus*, when the experiment upon lightning was firſt propoſed: what good conſequences were derived from that experiment: and why, upon further experiments and obſervations, ſuch points ought now to be laid aſide, when our intention is *not to make electrical experiments*, but by the means of conductors, *to preſerve buildings from the dangerous effects of lightning*.

Dr. Franklin, in his conjectures, that lightning and electricity were one and the ſame fluid, conſidered how he ſhould *invite*, or *bring down and collect the lightning*, ſo as to make experiments upon it.

And he concluded, from obſervation, that the likelieſt method would be, to make uſe of ſuch an apparatus for the purpoſe, as was moſt ſuſceptible of electric effects; or, in other words, ſuch an apparatus as would receive the electric fluid with the greateſt eaſe.

Repeated experiments taught him, that *metals* had the property of receiving that fluid, with more eaſe than other ſubſtances.

He alſo learnt, from the like experience, that metals *by being pointed*, were rendered ſtill more ſuſceptible of receiving it.

And therefore, he propoſed an experiment to be tried, " Whether it was not in our power to invite,
" or bring down the lightning, by an apparatus,
" conſiſting of an *electric ſtand*, and an iron rod,
" twenty or thirty feet in length, riſing upright
" from the middle of the ſtand, and at the top,
" terminating in a very *ſharp point*." This apparatus was recommended to be put upon ſome high building,

building, with the expectation, that if a thunder-cloud ſhould happen to paſs near this apparatus, ſome quantity of the lightning depoſited therein would probably be collected in the rod, by means of the very ſharp point, and the electrical ſtand at the foot of the rod

That this contrivance anſwered the end he firſt propoſed, we have had ſufficient evidence.

And it is no wonder if, after this great diſcovery, we find him, and other electricians, purſuing new experiments of this kind, and raiſing thoſe points higher into the air, to collect ſtill greater quantities of that fluid which occaſions lightning. Nor need we be ſurprized, after knowing that lightning could be brought down from the heavens by ſo ſimple an apparatus, and after experiencing its ſubtile effects to be ſimilar with the electric fluid, that the Americans, and others, upon Dr. Franklin's recommendation, adopted the principle of ſecuring their buildings from its dangerous effects, by raiſing above their houſes rods of iron, very *ſharply pointed,* and applying *wires* from the ends of thoſe rods, down the outſide of their houſes, to the ground.

But though there appeared many arguments at that time in favour of ſuch conductors, yet experiments and obſervations, at laſt, induced Dr. Franklin to *alter his opinion* in reſpect to thoſe *wires*, and to ſubſtitute in their place *rods of iron:* ſtill retaining the principle of having the rods at the top *ſharply pointed*; and many of the Americans, as well as Europeans, approved of the alteration, as appeared afterwards, from conſtructing their conductors accordingly.

About that time great attention was given, and many new experiments were made, in conſequence of the frequent dangerous effects, which lightning was obſerved to produce in ſome valuable buildings, by rending and daſhing to pieces very large ſtones and timbers, which were connected together by cramps and bars of iron: and at other times breaking and melting part of thoſe rods, and ſometimes *exploding wires*, even of a conſiderable thickneſs, like ſo much gunpowder.

From careful obſervations of theſe extraordinary appearances produced by violent ſhocks of lightning; and upon making other experiments relating to a certain reſiſting power *in*, or *upon*, all bodies, which appears to act againſt the attacks of lightning, as well as againſt the electric fluid, philoſophers were enabled to aſſign the reaſon, and, it is apprehended, upon a ſolid foundation, why Conductors ſhould be made of *metal*, in preference to all other materials; as the power of reſiſting ſuch attacks is leſs in metals than in wood, ſtone, or marble.

And that this reſiſtance might be the more ſimple and uniform, it appeared the moſt eligible to have the conductors made of *one continued piece of metal only*, and of *an equal diameter throughout*. But what that diameter ought to be, depended upon other circumſtances, ſome of which are taken notice of in a former paper, referred to above, which I laid before the Royal Society.

By this hiſtorical ſketch, we ſee the propriety of Dr. Franklin's introducing points, and the advantage philoſophy has derived from them: by aſcertaining that lightning and electricity are one and the ſame fluid: which appears to be diffuſed every where, at leaſt upon *this earth* and in *the atmoſphere.*

But when *curioſity*, which I apprehend was one of the firſt motives for introducing points to invite the lightning, was *ſatisfied*; and *experience* had taught us, that we had it in our *power* to *collect* that fluid which occaſions it: and when the *principle* of its action was from experiments thus inveſtigated and *aſcertained*, this manner of *invitation*, viz. by uſing points, ought, in my opinion, to have *ceaſed* *; becauſe a greater quantity of lightning, than we have yet experienced, may chance to attack us.

For we are ſo far from knowing how great the magazine of lightning may be in the heavens, or in the earth, when it is ready to diſcharge itſelf, either by one or more exploſions, that we are ignorant, *even of the quantity actually diſcharged*, whenever any ſtroke from lightning viſits us.

Nor can the ableſt philoſopher *fix the limits* of the *greateſt diſcharge* that may poſſibly happen.

Seeing then how vain it is to look for any thing like *abſolute ſecurity*, in all caſes, it ſurely behoves us to proceed with *caution*. And it is for that reaſon I have always conſidered pointed conductors as being *unſafe*, by their great readineſs to *collect the lightning in too powerful a manner*. And leſt the conductors, without ſuch points, ſhould be too ſlender for very

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* Unleſs where the electrician, like *Profeſſor Richmann* (who was killed by it) at his *own hazard*, chuſes to make further obſervations on lightning.

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violent attacks, in places of great conſequence, I have always recommended the having them above *four times* larger in diameter, than what are commonly made uſe of, to the end our ſecurity may be the greater, by opening a larger paſſage for any extraordinary diſcharge, and ſo far leſſening the danger to be apprehended from it.

I ought not, in this place, to omit taking notice of a paper, containing ſome further experiments and obſervations, which were produced at the committee, to ſhew, among other things, that pointed metals were more diſpoſed to receive the lightning, by virtue of a *repelling principle* in the lightning, as well as the electric fluid, which acted upon the *natural quantity* of the fluid contained within the metal, at a conſiderable diſtance from the *point*, cauſing, if I may be allowed the expreſſion, a kind of *vacuum* therein; but I ſuppoſe the author means to a certain diſtance only.

So far from diſputing this philoſophy, I readily admit the fact.

But, I am afraid, *every attempt* to prove that pointed conductors may be ſo diſpoſed to receive this fluid more readily, will not mend the argument in the leaſt; becauſe, the more we leſſen the power of reſiſting, even ſuppoſing the whole Conductor to be in that ſtate, the more we increaſe the power of invitation.

In regard to other experiments, with *locks of cotton* *, which are acted upon in a particular manner by the appoſition of points, and the concluſions drawn from thence, in favour of pointed conductors, as cauſing ſimilar effects upon the *fragments or ſmall clouds*, which, hanging below the thunder-clouds, have been ſuppoſed a kind of *ſtepping-ſtones*, for the lightning to paſs upon, towards the earth: ſuch pointed conductors being ſuppoſed to occaſion thoſe *fragments* to *retire up into the cloud* from whence they were ſuſpended; and on that account, to prevent a ſtroke from lightning, which might otherwiſe have happened, I ſhall, for the preſent, wave entering into this philoſophy, as I could wiſh the conjecture to be reconſidered; becauſe I apprehend it is liable to many objections, which to enumerate would carry me beyond the proper bounds of ſuch a paper as this. However, if the ſame opinion ſhould again be offered, and brought in argument, it may be worth while to enter more *deeply* into the enquiry.

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* Dr. Franklin's Experiments.

If thoſe gentlemen, who argued at the committee for the *neceſſity of points*, could have made it appear, that ſuch points draw off, and conduct away, the lightning *imperceptibly* and *by degrees*, *without cauſing any exploſion*, during a thunder ſtorm (which ſeems to have been once the opinion of Dr. Franklin) I ſhould readily have ſubſcribed to their Report.

But experience ſhews us, that the fact is otherwiſe: there being many inſtances, where violent exploſions of lightning have happened to *conductors* that were *ſharply pointed*. And *three* in particular, the accounts of which are inſerted in a publication of Dr. Franklin's *, where the *points* were *diſſipated*, or *deſtroyed*; and a ſmall part of an iron rod melted next the points of one of them; and alſo at the ſeveral crooked ends of the rods below, where they were hooked on to each other, and formed the conductor belonging to Mr. Maine in North America. But as thoſe letters are long, and contain ſeveral other curious facts, I ſhall reſerve them, together with ſome further obſervations upon the *nature* and *power* of that *reſiſting principle*, which is found to act ſo ſenſibly againſt the attacks of the electric fluid, or lightning, to ſome future diſſertation.

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* Dr. Franklin's Experiments, p. 394. 416, 417, &c.

There is no building, that I know of, more expoſed to this kind of danger, than the *Eddyſtone Lighthouſe*, as it ſtands upon a rock in the ſea, ſeveral miles from land. The fixing of a conductor to that building, was thought highly proper; and the fixing of a *point* upon it, as highly improper. It was therefore reſolved upon to put up a *conductor without a point*, that no more lightning might be unneceſſarily ſollicited to the building, and that all the lightening, which accidentally fell on it, might be conveyed away without injuring it. This conductor was *fixed* twelve years ago, and the building has ſince received no injury from lightning *.

There is another edifice of great conſequence, I mean St. *Paul's Church*, which ſtands much expoſed, from its heighth, to accidents by lightning. The dean and chapter of that cathedral, thought it an object deſerving the ſerious attention

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* N. B. A former building erected for the ſame purpoſe, upon this rock, was ſet on fire by lightning.

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of the *Royal Society*. A committee was therefore appointed, in conſequence of their application: and proper *conductors* were put up, in the ſeveral places where they were thought neceſſary, from the top of the *lanthorn* to the *ſewers* underground. And notwithſtanding particular care was taken, to have the additional metal either of a conſiderable diameter, or an equal quantity of it formed into other ſhapes, for the conveniency of the ſeveral places; yet part of thoſe conductors, conſiſting of iron, in the *ſtone gallery*, ſhewed marks of their having been made *conſiderably hot*, if not abſolutely *red*, by a ſtroke of lightning which happened in March laſt (as appears by a letter which I communicated to the Royal Society from one of the vergers of that church, Mr. Richard Gould) who had examined the conductors the morning following, along with Mr. Burton of the ſame cathedral *, and that the appearances were in general,

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* Mr. Gould acquaints us in his letter, that he examined the four conductors in the lanthorn and ſtone gallery of St. Paul's Church, the morning after the lightning happened. That no marks whatſoever appeared upon the conductor to the *ſouth*, which was the firſt he attended to. That he examined next the conductor to the *Weſt*, and obſerved a *thick ruſt* lying upon the pavement in the ſtone gallery, as if it had been cleaned off, from the conductor, with a tool: that ſeveral parts of the iron appeared *black*, particularly the ſcrews or nuts: ſomething like the effects left by gun-powder upon iron or ſteel, or a ſmoaky fire.

That the conductor to the *North*, ſhewed no marks, no more than that to the South.

But that upon examining the conductor to the *Eaſt*, he found ſtronger marks *abundantly*, than on the *Weſt* conductor, it ral, as the verger's letter related them to me. Mr. Delaval and myſelf attended, about a week afterwards, to obſerve them, and their particular

it being *much blacker*; particularly on the nuts and ſcrews: the ruſt lying in greater quantities on the pavement. *And the extreme part of the conductor that goes into the water trunk*, ſeemed like a piece of iron *newly taken out of a forge* by a ſmith, without working it on the anvil.

N. B. Mr. Gould has ſince added to the account in his letter, ſome circumſtances which I apprehend ought not to be omitted. He ſays, that where the end of the conductor, on the Eaſt ſide, points towards the water trunk, a ſtone ſurrounds part of it, leaving an interval, half an inch wide or more, between them, and about four or five inches long, which is a little more than the breadth of the conductor. That this interval was *filled up with dirt*, and had been ſo for ſome time, occaſioned by frequent ſhowers of rain waſhing the pavement in the ſtone-gallery. That, after the lightning happened, he obſerved a *hole* was made through the *dirt*, *one quarter of an inch in diameter*, and about *two inches in length*. That the hole was cloſe to the iron; and that, upon ſtooping down his head, he perceived a very diſagreeable *ſmell of ſulphur* from the ſtone, dirt, and conductor, particularly the laſt.

Upon hearing this account, Mr. Delaval and myſelf, a few days ago, went and examined the conductors again; but more carefully than before. For, upon cauſing the ſtone to be removed, which covered the top of the water trunk, we had an opportunity of examining near two feet more of the iron which points to the water trunk, than we could perceive before this ſtone was removed. When we obſerved, that the conducting iron did not touch the lead. We likewiſe obſerved, that there was a *very thick coat of ruſt* all over that part of the iron; *particularly at the end next the lead*, where the water entered the trunk.

As the neceſſity of attending to theſe circumſtances will be obvious to any one, who is but in the leaſt degree acquainted with theſe reſearches, *the danger of neglecting them will be ſeen in the ſtrongeſt light, by the gentlemen of the committee* who recommended the conductors for the ſecurity of that Cathedral.

ſituations; with the circumſtances attending them, when we were very well ſatisfied with his account, notwithſtanding it had rained in the *interim* for three days together.

It is worthy of note, that thoſe conductors did *not terminate in a point*, nor was any *point put* upon the *croſs at the top*.—And yet Dr. Franklin was of that committee.

If points are ſo eſſential to our ſafety, why was not the reaſon enforced at the committee, for having them on that capital edifice? For my part, I think it was a happy circumſtance, that there was *no point* fixed upon the top of the church, to ſollicit a greater quantity of lightning at that moment, than what fell upon the conductors, circumſtanced as they were: as *that quantity* was great enough to *heat ſo conſiderably* a *bar of iron*, near *four inches broad*, and about *half an inch thick*.

This powerful effect, reminds me of another inſtance ſtill more extraordinary, which happened in Martinico, and is related by *Captain Dibden*, where a bar of iron, *one inch in diameter*, was by a violent ſhock of lightning *reduced in one part of it*, *to the thickneſs of a ſlender wire only*. See Ph. Tr. Vol. LIV. p. 251.

Since then we are at all times ignorant of the quantity of *lightning in the* earth and its atmoſphere; and the difference in the effects, between blunted and pointed, ends, in cauſing a diſcharge in our electrical experiments, appears to be as *one to twelve*; it is eaſy to comprehend the very great danger this noble fabrick has probably eſcaped, by having no pointed apparatus upon it.

From the above obſervations, I am naturally led to conſider a part of the proceedings of the committee, reſpecting the *magazines* at *Purfleet*; when a certain number of conductors, with tapering points at the top, were reſolved upon, as neceſſary, to protect the ſeveral buildings where the powder is depoſited. For it was *agreed* upon at the ſame meeting, that the *Board-houſe*, which is a large building for the uſe of the board-officers, and which ſtands conſiderably higher than the magazines, as was obſerved above, *did not require any point at the top*: becauſe it was apprehended to be *perfectly ſecure*, by reaſon of the copeings on the roof, the gutters and pipes to carry off the water, being all of lead: and further, becauſe thoſe pipes communicated with two wells, which always contained water.

I was not a little ſurprized at this laſt reſolution, which appeared to be ſo inconſiſtent with the former. Becauſe, if points were neceſſary in one place, they ought to be ſo in another. And on the other hand, if the Board-houſe is ſecure by the leaden accidental conductors, which have no points, why ought not the magazines to be equally ſecure, when put into the ſame circumſtances?

I therefore enforced the *inconſiſtency* of ſuch a reſolution in the ſtrongeſt terms. Notwithſtanding which, the gentlemen, at that time, thought proper to confirm their reſolution. However, at the next meeting of the committee, I obſerved that they had been pleaſed, in the mean time, to make an amendment in favour of points for the board-houſe; which amendment was no ſooner propoſed, than approved of.

Why my obſervation was rejected at the preceding meeting, I muſt leave to the judgment of others. But it certainly carries an appearance, as if *manifeſt contradiction*, upon further reflection, muſt have been the *cauſe* of that alteration.

And I am inclined to believe, from ſome gentlemen of the committee expreſſing their opinion, "*of its being a matter of mere indifference whether* "*blunted or pointed conductors were made uſe of,*" that they have not conſidered this ſubject, with all the due attention which ſo important an object deſerves.

For if our experiments ſhew, that *points*, from the *nature* of their *ſhape*, and *other* circumſtances attending them, reſiſt the attacks of this fluid leſs than blunted ones; and that blunted conductors, of proper dimenſions, are ſufficient to convey away the lightning *ſafely*, whenever it attacks them; why ſhould we have recourſe to a method, which is at beſt uncertain; and which ſome time or other may be productive of the moſt fatal effects?

But perhaps no argument can be brought with more force againſt the principle of points, than Dr. Franklin's own words, which are publiſhed in his experiments, p. 481, where he declares *poſitively*. "Buildings, that have their roofs covered with "lead, or other metal, and ſpouts of metal conti-"nued from the roof into the ground to carry off "the water, *are never hurt by lightning*; as when-"ever it falls on ſuch a building, it paſſes in the "metals, and not in the walls."

This is the caſe with the *Britiſh Muſeum*, a building alſo of conſiderable conſequence, where there are no other *conductors*, than what are formed by the *copeings*, *gutters and pipes*, which are all of lead, and communicate with the ground. Now it is from the great quantity of metal contained in the ſeveral pipes, together with the other circumſtances attending them, that I conſidered that building (in a former paper laid before the royal ſociety) as being ſufficiently ſecured, from thoſe dangerous accidents.

But if any gentleman ſhould be diſpoſed to entertain a doubt about it, or indeed of any other part of my reaſoning on this ſubject, a *declaration* of thoſe doubts may be attended with good conſequences, as they will neceſſarily open the door to a more minute inveſtigation.

I have now, Sir, gone through the reaſons which I propoſed to lay before the royal ſociety for the rejecting of points. And I am very ſorry, in the courſe of this letter, to have been under the neceſſity of mentioning any differences in opinion, which paſſed between the members of the committee, to whom this important matter was referred. I think, however, I ſhall ſtand excuſed to the ſociety, and the public, when it appears, as I hope it now ſufficiently does, what my motive has been; namely, to ſtate clearly, and impartially, the objections which I conceived to lye againſt pointed conductors: and to diſcloſe *without any reſerve*, the principles on which ſuch objections are grounded.

I am, SIR, with the greateſt reſpect,

Your moſt obedient, and moſt humble ſervant,

8th December, 1772,
Great Ruſſel-ſtreet,
Bloomſbury.

Benjamin Wilſon.

P. S.

P. S. Mr. Delaval, who was one of the committee, has given me leave to inſert his opinion upon this ſubject; which is this. That he concurs with me in thinking that ſuch conductors as are elevated higher than the buildings to which they are applied, or are pointed at the top, are *improper* and *dangerous*.

He was deſirous of delivering his opinion at the committee: but, as the meetings of it were held in the ſummer only, his abſence from London prevented his attendance.